Report on Surface Geology. By ROLLIN D. SALISBURY, in Annual Report of the State Geologist of New Jersey, for 1893, pp. 35–328. Pl. 1–6, and three large-scale, folded maps.

This is the third report of progress which has appeared on the detailed studies of the surface geology and topography of New Jersey now being made by the Geological Survey of that state. The results recorded are the outcome of the field work in 1893, conducted by Professor Salisbury, who was assisted for longer or shorter periods by Messrs. H. B. Kümmel, C. E. Peet, A. R. Whitson, and G. N. Knapp. The area examined is practically the northern third of the state. Observations were confined to the records of glaciers, and to certain gravel deposits more or less closely associated with ice invasions. The order of treatment is chronological, beginning with the oldest records that have been thought to belong to Pleistocene time.

The Yellow Gravel.—The occurrence of detached areas of gravel and sand, from the latitude of Staten Island southward has been known for several years, and usually designated as "Yellow Gravel," and referred in part to the Columbia and Lafayette formations. When traced southward, the areas occupied by this deposit became larger, and are believed to coalesce finally so as to form a continuous sheet, having a wide geographical range. Along its northern margin this deposit attains a maximum elevation of nearly 400 feet above the sea, and declines gently southward. It has usually been considered a single terrane, but the report before us proves that it includes at least four distinct deposits differing widely in age. Three of these divisions have been given local names as follows, beginning with the oldest: Beacon Hill, Pensauken and Jamesburg. The fourth and youngest phase is not named.

While the more obtrusive lithological characteristics of these four terranes are similar and in a general way are expressed by term Yellow Gravel, yet careful study has shown that they differ widely in composition and that the pebbles they contain were derived from widely separated sources. The Beacon Hill gravel is characterized by the presence of yellowish quartz, chert, flint and sandstone pebbles, and by the entire absence of shale and granitic material. The constituent pebbles range up to three inches in diameter, and cobbles and moderately worn slab-shaped fragments, two feet in diameter are occasionally found. In the Pensauken which was derived largely from the Beacon Hill, there is an addition of material from widely separated sources to

the north, much of which is of such a size and shape as to suggest that ice may have assisted in its transportation, though no glaciated material has been found in it. The advanced stage of decay observed in the pebbles and bowlders of this deposit shows that it has been long exposed to the action of the atmosphere, or perhaps more properly, to the percolation of surface water. The third deposit, the Jamesburg, is markedly heterogeneous. It is more loamy than the preceding, but contains cobbles and even bowlders of large size, some of which differ in character from those of the Pensauken, and were derived from different sources; glaciated bowlders are occasionally found. An important change in geography, at least, if not in reference to glaciation, is thus indicated. The lithological characteristics of the fourth stage are not stated, but presumably they are such as would result from a working over and commingling of the material composing the three earlier deposits. It is thus evident that the lithological differences in the several divisions of the Yellow Gravel are sufficient in themselves to warrant a subdivision of what was formerly considered the record of a single period of deposition.

The Beacon Hill gravel was laid down on the even and uneroded surface of the Cretaceous. Elevation followed and stream channels were sunk through the gravel and into the marl beneath. In these channels in part, the Pensauken was deposited during subsequent submergence. In the Pensauken there are fragments of ferruginous concretions derived from the Cretaceous; these are absent from the Beacon Hill gravel, showing as do other facts, that the Cretaceous terrane was not cut by stream channels until after the first division of the Yellow Gravel was laid down. Another elevation followed the Pensauken stage, and during a subsequent submergence the Jamesburg was spread over the channeled surface of the second deposit. The fourth stage of submergence was of minor importance; its records are confined to the seaward margins of the region, and vary in elevation from twenty-five to forty-five feet. This is evidence of a moderate submergence subsequent to the Jamesburg stage, or may possibly represent a halt in the process of upheaval that closed that time of deposition. Thus, by unconformities, the Yellow Gravel is shown to belong to at least three periods of subsidence, separated by intervals during which the region was elevated and exposed to erosive agencies.

The Beacon Hill gravel is known from its stratigraphic position to be post-Cretaceous. While evidence of its precise position in the

geological column is lacking, there are reasons for believing that in part at least, it is Miocene. The last subdivision of the Yellow Gravel is thought to have been either contemporaneous with the last glacial epoch or more recent.

In reference to the length of time represented by these deposits, it is stated that the interval between the first and second divisions was probably much longer than the time which has elapsed since the second; and that the interval between the second and third stages was longer than the time since the third.

The relation of the later phases of the Yellow Gravel to Pleistocene glaciers, and the probability that the Jamesburg formation at least was deposited in part through the agency of floating ice, and possibly in the vicinity of glaciers, are discussed and the weight of the evidence indicated. The presence of a great variety of rock materials, including large bowlders, in the Pensauken, and the occurrence of that deposit beneath "extra-morainal glacial drift," seems to suggest that there may have been a time of glaciation of older date than the earliest evidence of glacial work otherwise recognized in the region studied. The absence of glaciated stone from the Pensauken, makes it impossible to connect this formation with the ice with any degree of certainty.

Extra-morainal drift.—The true nature and significance of certain detached areas of much weathered morainal material, south of the great terminal moraine that crosses northern New Jersey, has been the source of controversy, but the mass of evidence presented in the report before us must silence opposition, as the glacial origin of the material referred to is placed beyond all doubt. The distribution of this extra-morainal drift from the Delaware eastward, for about halfway across the state, is accurately mapped, but its extension in the lower country to the eastward is indefinite and seemingly indeterminate. Its maximum extent south of the terminal moraine is twenty-two miles, and the area more or less completely covered by it, about 450 square miles. This older drift occurs in detached areas and bears evidence of marked decay and extensive erosion. A large part of the region it once covered retains only scattered bowlders to show the nature of the former covering. The southern limit of the ice during this earlier invasion is approximately indicated on a large scale map which also presents much additional data concerning later glacial deposits.

The care with which the distribution, character, weathering, erosion, etc., of the extra-morainal drift has been studied and the amount of

evidence on which the conclusion as to its nature and age are based, may be judged to some extent by the fact that fifty pages are devoted to a detailed record of observations.

The terminal moraine.—Next in order in this historical study of Pleistocene of New Jersey come fresh observations concerning the great terminal moraine that crosses the state. The course of this prominent topographical feature has been re-traced and mapped with care, and the characteristics of its varied features described and their origin discussed. Attention is directed to the influence of pre-glacial topography on the trend of the moraine. Where the country is low and offered few obstructions to the advancing ice, the moraine extends farther south than on higher and more rugged areas. The same relationship between the trend of the moraine and the character of the antecedent topography, appears also when minor features are studied. Thus at the crossing of every pre-glacial valley the moraine bends southward showing that the valley facilitated ice movement. Local elevations on the other hand caused the moraine to recede from its normal course.

The moraine is a conspicuous topographic feature, especially when seen from its outer or southern face. In places it rises abruptly to the height of 140 feet above the over-washed gravel fringing its outer margin. Its inner or northern slope is not strongly pronounced and frequently merges with gentle gradations into the drift-covered country that it borders. The distinction between the moraine as a topographic feature and the topography of the moraine is emphasized. Special features in the relief of the moraine and characteristic examples of morainic topography are described and illustrated by sketches.

The characteristics of both the outer and inner margins of the moraine are described in detail, and many observations recorded in reference to its width, depth, and the character of the material of which it is composed. Its course and width, and the extent of the over-washed apron of gravel bordering it on the south, are shown on a large-scale map of the state.

Drift deposits made under the influence of stagnant ice.—The origin of certain gravel terraces with irregular margins and projecting spurs, occurring on the sides of valleys, is explained on the hypothesis that the centers of the valleys where they are found were formerly occupied by stagnant ice, and that sand and gravel were swept into depressions bordering it on either side, and into crevasses in its margins. A *mold* of the ice, as it may be termed, was thus formed. When

melting occurred, the gravel and sand were left in terraces with irregular valley slopes, corresponding with the irregularities of the ice against which they were deposited.

These terraces, and especially their projecting spurs, formed by the filling of crevasses, present many of the features of kames; they are therefore named *Kame Terraces*. This is a welcome addition to topographic nomenclature. The irregular outer margins and projecting spurs of kame terraces seem to make them specifically distinct from similar deposits formed on the borders of moving glaciers.

Drift phenomena of the Palisade Ridge.—The records of a detailed study of the glaciation of the Palisade trap ridge on the west side of the Hudson, occupies sixty-seven pages of the report. This long, even-crested monoclinal ridge, rising from 200 to 400 feet above tide, was crossed obliquely by the ancient glaciers and offered a stubborn resistance to their advance, as is shown by its worn and striated surface. Many measurements of the direction of striæ are shown on a large-scale map, which indicate that the average direction of the ice movement was about S. 44° E. In some instances there are two series of striæ on the same surface, as is common in many formerly ice-covered regions. The most probable explanation of these double records, according to Salisbury, seems to be that during the advance and again during the retreat of the ice, there were variations in its direction of flow, owing principally to the expansion and contraction of the glacial lobe under which the Palisade ridge was located.

All of the peculiar markings known to have been made by glaciers on rock surfaces, such as striæ, grooves, chatter marks, disruption gouges, etc., were discovered on the Palisade Ridge, as well as perched bowlders, *roches moutonnèes* and other similar records. The till covering a large part of the ridge presents interesting features, among which are blocks of sandstone, at elevations from 300 to 500 feet above the ledges from which they were derived, and illustrating the lifting power of glaciers.

The borders of the Palisade Ridge, especially on the northwest—the direction from which the ice came—are in places heavily encumbered with stratified gravel and sand, which record the abundance of the drainage from the melting ice.

A yellow loam occurring in detached areas at various elevations on the Palisade Ridge is the subject of several ingenious hypotheses. The most plausible explanation of its origin seems to be that it was accumu-

lated on the ice, partially as dust, and left on the surface of the till when the melting occurred. The fact that superglacial material, especially on stagnant ice-sheets, is subjected to many changes of position and experiences many falls, and is thus broken, and that it is also disintegrated on account of changes of temperature, might, it seems to the present writer, be cited in connection with the hypotheses suggested in reference to superglacial origin of the loam.

Lake Passaic.—The conclusion that a large glacial lake formerly existed in the drainage basin of Passaic River, in north-central New Jersey, was advanced by Professor George H. Cook, the late state geologist, in his annual report for 1880. The strength of the evidence on which this conclusion was based has since been questioned, and several geologists who have visited the region have doubted if Lake Passaic, as the old lake was named, ever had an existence. This subject has been restudied by Salisbury and Kümmel, and so much consistent evidence advanced that the former presence of the water-body referred to must not only be accepted, but given a prominent place among examples of ice-dammed lakes of the nature of Merjelen Lake, Switzerland, the first existing example of the type to be studied.

The trap ridges of central New Jersey, rising above low-lying areas of Newark sandstone and shale, have such a form that an ice-sheet advancing from the north would occupy the depressions through which the drainage escapes, and thus shut off a considerable basin from free discharge to the sea. This in general was the history of the origin of Lake Passaic. The evidence furnished by lacustral deposits, terraces and other shore features, as well as by the position of the great terminal moraine, although indefinite at times and seldom pronounced, is, on the whole, sufficient to prove the former presence of Lake Passaic and to admit of the mapping of its shores. Like most lakes held by ice dams, the glacial lake of New Jersey had a varied history, several chapters of which have been deciphered. During its maximum it was about thirty miles long from north to south and ten miles broad at its widest part, and over 225 feet deep.

Since the lake was drained, the region it occupied has undergone changes in elevation and the old shore lines are no longer horizontal. An increase in elevation from south to north of sixty-seven feet in thirty miles, or at the rate of 2¼ feet per mile, has been shown to exist. These changes are supposed to be due to a re-adjustment of isostatic conditions after the disturbances produced by the weight of the Pleistocene ice-sheets.

This admirable report of progress, covering nearly 300 pages and accompanied by three large-scale maps and dealing with the surface geology of perhaps one-third of New Jersey, establishes a precedent that those in charge of other geological surveys will do well to follow. It will no doubt be a surprise to many who read the topographic history of New Jersey as interpreted by Salisbury, to learn that in the surface features of the land there is preserved a record that is fully as interesting and instructive as the history of past faunas and floras, which for a long time was considered the special field of the geologist.

Geologists and geographers alike will await with interest the appearance of the final monograph of the surface features of New Jersey, which the reports of progress already issued lead them to expect.

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Bulletin of the Geological Society of America. Vol. VI., pp. 103–140; Pl. 1. *Reconstruction of the Antillean Continent.* By J. W. SPENCER, A.M., Ph.D., F.G.S. (L. & A.). January, 1895.

In this paper the author arrives at some very striking conclusions concerning the elevation of the Antillean island during Pliocene and early Pleistocene times. The deep depressions, which cross the continental shelf and which are believed by the author to be drowned valleys, furnish him data by which to estimate the amount of such elevation. Between Cape Hatteras and the Bahama Islands four clearly marked depressions cross the continental plateau. Three of them are in line with rivers of the coastal plain. These fjords can be traced for distances between 200 and 300 miles, and into water 12,000 to 14,000 feet deep. One of them sinks over 5000 feet below the level of the submerged plateau and is comparable to the Grand Cañon of the Colorado. Between the Bahama islands are depressions traceable for distances up to 350 miles, and from depths of about 2000 feet into waters 10,000 to 14,000 feet deep. In the Gulf of Mexico similar submerged valleys exist, and in most cases they are closely related in position to existing rivers. They are traceable into water 10,000 feet deep. Their bottoms sink from 800 to 3000 feet below the top of the valley sides, and they are several miles in width. Other fjords occur off the coasts of the West Indies, and around the Caribbean Sea, some of which are traceable into depths of 12,000 feet.

The author concludes that these are land valleys which have been